Introduction to Robotics

Coursework

Design and Control of Kinematic Controlled Manipulators

The challenge is to design, develop and control a manipulator/robot based upon one of the challenges listed on pages 2 - 5.

Requirements:

- Use CAD to create a 3D model of your design.
- Test and analyse the structural elements utilising FEA
- Simulate the movement of your design
- Use CAM techniques to create your design physically
- Calculate the appropriate Kinematics for your system for cartesian control
- Program your new manipulator/robot with embedded technology

You will then need to demonstrate your manipulator/robot to other students, academics and guests, as part of a **module showcase**.

This is a **group project** with **group demonstration** and a **group report**. However, **each** member will have to submit a separate **'work ethic'** document. This document must include a summary from that individual, about their input on the project and how other members of the group contributed. This will be used to help determine individual marks.

Due to the class size there will be:

10x Groups of 4

2x Groups of 3

4x Labs each week

Groups will then be subdivided into two sets. Each set will then attend their related Lab session on either Monday @ 16:00-18:00, Thursday @ 9:00 – 11:00, Thursday @ 11:00 – 13:00 or Thursday 16:00 – 18:00.

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-------------------- Challenges --------------------

As a group you must decide on one of the following project challenges and then update the group document on the DLE with:

- Names of everyone in the group
- Challenge selected
- A Professional group 'name'

Challenge 1: Teleoperated Space Manipulator

Background:

Currently there are large-scale robot arms being used in space operations, for example on the International Space Station (ISS). These robot manipulators are used to help assemble the station, move astronauts around (with foot restraints), and to dock some spacecraft to the station. These manipulators are typically controlled by astronauts inside the space station, however there has been significant interest in teleoperating such robot arms, in orbit and perhaps on the moon, from ground stations on earth. This would be enabled by multiple camera views of the arm in operation. This would enable many more robot arms to be used, and to reduce the costs associated with keeping the astronauts occupied with performing these tedious tasks. However, when teleoperating from earth there can be considerable time-delays on the communications, often up to multiple seconds from joystick control input to visual feedback.

Goal:

Your goal is to design a small robot manipulator for space teleoperation (for 1-G environment, sorry no spaceflight possible during duration of this project) and simulate the limited camera views and time-delay in the human-robot control loop. The arm design should be emulating the design of typical space manipulators but at a small scale, see for example the Dextre, Canadarm2 and the old Shuttle Remote Manipulator System: SRMS.

Constraints:

This project would require at least one camera view, preferably multiple, and you would be asked to design an experiment to test the system simulating the distance/delay (by e.g. sitting in an adjoining room). The task could be to ideally grasp and move a set of modules (say a set of cylinders/cubes etc sat loosely in a set of slots) to another location (say another set of slots), and back again in the minimum amount of time. The minimum movement distance for each module to be moved is 25 cm. The arm should be teleoperated with your preferred input device. Additional autonomous functionality would be a bonus.

Challenge 2: Pick and Place

Background:

In industry, the majority of manufacture is moving towards automated production. Examples such as the ABB industrial arm or the Toshiba arms can move huge masses in very precise motions, moving part A to part B or welding/soldering part A to part B. This is a fundamental requirement for such mass production.

Goal:

Design and construct a robot and system that can inspect/manipulate an object (such as a toy or sweet) in a useful manner to achieve a task. For example, a single arm and supporting structure to automatically construct a Lego car/house, or an arm that can take a biscuit and cover it in chocolate and sprinkles to replicate a modern chocolate factory.

Constraints:

The main limitation for this project is that one of your arms/manipulators must have at least 5 D.o.F.

Challenge 3: Redundant Freedom Arm

Background:

A redundant manipulator has more than six degrees of freedom (DOF) which means that it has additional DOF that allow the configuration of the robot to change while it holds its end-effector in a fixed position and orientation. Redundant robots can also fully position/orientate their tool in a given position. But while 6-axis robots can only have one posture for one given tool position, redundant robots can accommodate a given tool position under different postures. This is just like the human arm that can hold a fixed handle while moving the shoulder and elbow joints. This is useful when avoiding obstacles while reaching for an object. A typical redundant manipulator has seven joints, three at the shoulder, one elbow joint and three at the wrist. This manipulator can move its elbow while it maintains a specific position and orientation of its end-effector. A snake robot has many more than six degrees of freedom and is often called hyper-redundant.

Goal:

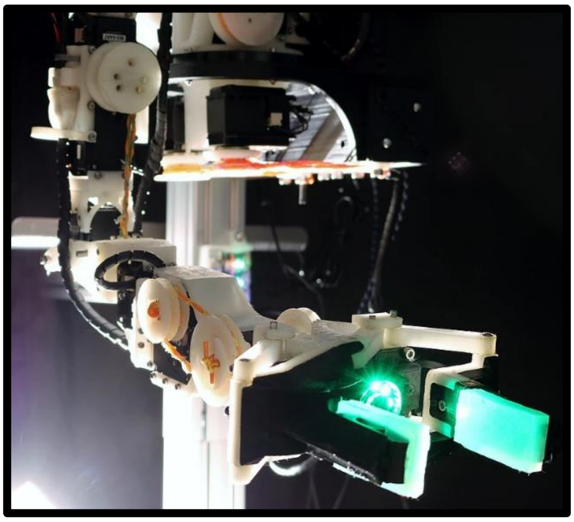
Design a robot manipulator with redundant degrees of freedom (seven or more joints).

Constraints:

Design the robot in such a way that you have one 5 DOF section where you can easily solve for the inverse kinematics etc. Add additional DOF towards the hand (or at the base) that make the overall design redundant.

Challenge 4: Visual Servoing Tracking Robot

Background:



Visual Servoing is a method for robot control where the sensor used is a camera (visual sensor). There are two fundamental configurations of the robot end-effector (hand) and the camera: Firstly, eye-in-hand, or end-point open-loop control, where the camera is attached to the moving hand and observing the relative position of the target. Secondly, eye-to-hand, or end-point closed-loop control, where the camera is fixed in the world and observing the target and the motion of the hand. Visual Servoing control techniques are broadly classified into the following types:

Image-based (IBVS), Position/pose-based (PBVS), Hybrid approach

Goal:

Your goal is to design and construct a robot and system that can be controlled to track a recognizable object (a face, a ball, a toy, etc.) and follow it around while it is in view of the camera (perhaps grasp as well?). Your robot arm should be designed to support this, with a suitable configuration of DOF, and a suitable workspace.

Constraints:

Assume you only have access to a simple web camera, and that your vision algorithms will be as basic as possible (focus is on designing and controlling the robot arm). For example, tracking red objects only, or faces only.

Challenge 5: Walking Robot

Background:

Robots with legs have always been a fascination. They may not be as easy or affordable to construct as wheels or as stable as tracks, but they allow for adaptive organic movements. They allow for traversal of both flat and un-even ground and bipedal robots would be capable of traversing in a human society as easily as a person. They can also isolate their main body from dangerous terrain and regulate their stability avoiding undesirable footholds. Additionally, walking can be very energy efficient if balanced correctly with an appropriate walking gait.

Goal:

Your goal is to design and construct a robot and system that can walk. This can be a bipedal robot, quadruped robot or a new evolution. Come the end, your robot must be able to walk in a stable fashion, and with a minimum of 2 different walking gaits.

Constraints:

This challenge may require the use of many servos. Before going ahead with your quadruped robot design, please consult an appropriate member of staff regarding the number of required motors to ensure you do not get carried away with your design.

Important Note:

This is a very open coursework with a lot of freedom regarding what you can build and design. It is important to remember that a working project will grade better than a project that doesn't. Ensure to **plan a strategy** with **achievable goals** that can be shown and build your project upon each step. For example, if you are building a pick and place robot. First sketch, design and create a 5-axis robot, initially this can be done out of cardboard. Once you are happy with the design and dimensions, then you can begin modelling and constructing your prototype. Next would be to implement your kinematic controls. Then you can iterate and improve the arm and the task that you would like it to perform.

Additionally, this project has been designed to help your own CAD, CAM and kinematic abilities. As such, **you must design EVERYTHING from scratch**. If any of your designs are discovered to be downloaded from the internet from sources such as; Thingiverse, GrabCAD, Turbosquid, YouMagine, 3D Wearhouse, Sketchfab, Yeggi, STLFinder, etc. or shared between groups, your project will be **DISQUALIFIED** and you not receive a mark.